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Description

This invention relates to vehicle electronic clutch control systems for the automatic control of a friction clutch situated in the drive line between a vehicle engine and a transmission.

The invention relates in particular to an electronic clutch control systems for a rotary friction clutch having a clutch control signal generator responsive to a vehicle operating parameter and from which a command signal is derived which dictates the state of engagement of the clutch, a clutch actuator control means responsive to the command signal for operation of the clutch and including a comparator that receives the command signal and a transducer responsive to the position of the clutch to produce a feed back signal which is fed into the comparator for comparison with the command signal. Such a control system is described in our published European Patent Specification No. 0 038 113 and will be hereinafter called a clutch control system of the kind referred.

A problem associated with clutch control systems is that because the clutch position feedback loop utilises an actual clutch position signal derived from a transducer responsive to the position of the clutch operating mechanism, then the position signal is not necessarily a reflection of the relative positions of the clutch friction surfaces. This is particularly true as the clutch plate wears and because of production tolerances in the operating mechanism of the clutch.

United States Patent 4023660 discloses an electronic control system for a rotary friction clutch in an engine driven vehicle for starting the vehicle from rest comprising a clutch control signal generator which produces a control signal in response to a vehicle operating parameter (the degree of throttle opening) and from which a command signal is derived which commands the state of engagement of the clutch. A clutch actuator control means responsive to the command signal for operation of the clutch includes a comparator that receives the command signal and a transducer responsive to the position of the clutch to produce a feedback signal which is modified by a wear compensation signal derived from a wear compensator so that the feedback signal is altered in dependence on the state of wear of the clutch, the altered feedback signal also being received by the comparator. In this prior proposal, the wear compensation signal is intended to correspond to the actual signal from the clutch position transducer at the stage of clutch engagement when the friction faces are just touching. For derivation of this signal, the actual clutch position signal when the clutch is fully engaged is combined with a preset signal intended to represent the difference between the fully engaged and just touching positions. For the system to work accurately, there is a requirement that throughout the life of the clutch the distance travelled by the clutch between its fully engaged state and the just touching state remains constant. To use a standard pre-set signal would also require identical distances between the fully engaged and just touching states for a batch of clutches and thus would not allow for manufacturing tolerances. In practice there are substantial variations in the distance between the fully engaged and just touching states, both from one clutch to another due to manufacturing tolerances and due to the structure of the clutch itself. For example, nonlinearity in some parts of a clutch, wear of the operating mechanism and variation in resilience over the life of the clutch can all affect the distance between the fully engaged and the just touching states. For these reasons a feedback signal derived from the fully engaged condition and a pre-set value is not accurate and can lead to unsatisfactory clutch operation. Another problem associated with the system of US Patent 4023660 is that it operates in response to throttle position. A suddenly introduced large throttle opening introduces a correspondingly sudden clutch engagement which in an extreme case could stall the engine before engine speed has built up in response to throttle opening. Similarly, with small throttle openings just above fifteen per cent of full throttle opening, clutch engagement is only just beyond the just touching state so that clutch slip can occur over a substantial period of time leading to clutch overheating.

An object of the present invention is to provide an electronic control system for a rotary friction clutch in which an improved arrangement for wear compensation is provided.

In accordance with the present invention there is provided an electronic control system for a rotary friction clutch in an engine driven vehicle for starting the vehicle from rest comprising a clutch control signal generator which produces a control signal responsive to a vehicle operating parameter and from which a command signal is derived which commands the state of engagement of the clutch, a clutch actuator control means responsive to the command signal for operation of the clutch and including a comparator that receives the command signal and a transducer responsive to the position of the clutch to control a feedback signal which is modified by a wear compensation signal derived from a wear compensator so that the feedback signal is altered in dependence on the state of wear of the clutch, the altered feedback signal also being received by the comparator, characterised in that the command signal is derived by integrating the control signal in an integrator, the wear compensator comprises a first detect means for sensing the threshold value of the control signal and a second detect means for sensing when the command signal has passed the threshold value and a wear signal generator is responsive to detection of the threshold values of the control signal and the command signal during an initial clutch engagement to set automatically a wear compensation signal for subsequent clutch engagement.

Preferably the control signal is responsive to an engine speed signal derived from an engine

speed sensor such that the engine speed is controlled to a constant level during clutch engagement.

Preferably the wear signal generator includes a counter which is started in response to the control signal reaching a threshold level indicative that clutch engagement should commence and is stopped in response to the command signal reaching a threshold level indicative that the clutch is engaged sufficiently to maintain the desired constant engine speed.

In an alternative system the feedback signal can be modified by a coarse position signal produced by a coarse positional means comprising a desired clutch position reference signal generator, connected to the input of a comparator, whose other input is connected to the feedback signal and whose output is connected to an AND gate for control of a compensator signal generator for modification of the feedback signal, the trigger closing the AND gate and stopping the compensator signal when the feedback signal approaches the value of the desired position.

Conveniently the above preferred and alternative systems can be combined so that a coarse position signal is summed with the wear signal prior to the combined signal being utilised to modify the feedback signal.

The invention will be described by way of example and with reference to the accompanying drawings in which:—

Fig. 1 is a schematic diagram of a clutch control system according to one embodiment of this invention;

Fig. 2 is a detailed circuit of the wear compensator utilised in Fig. 1;

Fig. 3 is a graph of input versus output for amplifier 42 in Fig. 2;

Fig. 4 is a graph of input versus output for amplifier 41 of Fig. 2;

Fig. 5 is a graph of input versus output for the zero detect means 31 of Fig. 2;

Fig. 6 is a schematic diagram of a second clutch control system according to an alternative embodiment of this invention;

Fig. 7 is a portion of the detailed circuit showing in particular the error signal valve detect means, the command signal threshold valve detect means, and the throttle position differentiator; and

Fig. 8 is a further portion of the detailed circuit showing in particular the oscillator, AND gate, comparator and the coarse positional means.

The motor vehicle clutch control system illustrated in Fig. 1 includes an engine speed sensor 11 which produces a signal V_1 proportional to a vehicle operating parameter, namely engine speed, and a reference signal generator 12 that produces a reference signal V_R. The reference signal generator 12 produces a signal V_R that can be set to be the same value as a signal obtained via engine speed sensor 11 at a particular engine speed which may be fixed at, say 1000 rpm, or may be varied depending upon engine torque demand, for example the signal may be increased to become equivalent to a higher engine speed for hill starts. This can be achieved by having a throttle potentiometer signal which is proportional to throttle opening, combined with the reference signal. As is described in our published European Specification No. 0 038 113 the throttle signal is proportional to (1 − throttle opening) so that the signal decreases as the throttle opens. The throttle potentiometer signal is then inverted before combination with the reference signal V_R but in this case is used in its raw state.

A comparator 13 receives the reference and engine speed signals V_1 and V_R and measures the difference between the two signals to produce an error signal E. The error signal is positive when V_1 is less than V_R, and becomes negative when V_1 exceeds V_R. The error signal constitutes a clutch control signal and is utilised in a manner to be described for controlling an actuator 22 that operates the clutch 23 to vary the state of engagement of the vehicle clutch 23 to alter the engine speed with subsequent variation of the engine speed signal V_1 to approach equivalence with the reference signal V_R and make the error signal tend to zero.

The error signal E is fed into an integrator 14 which produces a command signal C which is fed into a clutch position control loop. The integrator 14 is of the type disclosed in our co-pending Application No. 81.302741.4 and has two response modes depending upon whether a capacitor in the integrator is connected in or out of the error signal path. The integrator 14 acts in the inverting sense and a negative error signal i.e. when $V_1 > V_R$, produces a positive command signal C from the integrator.

The clutch control loop comprises a comparator 17 which receives the command signal C for comparison with a signal S_T which is derived from a wear compensation signal S_W, a clutch position feedback signal S_P and a throttle position signal V_T. The clutch position signal S_P is generated by a travel transducer 18 responsive to the position of the clutch 23 and the throttle signal V_T is generated by a potentiometer 40 coupled to the butterfly valve in the carburettor. The signal from the comparator 17 is fed into a clutch actuator control 19 which includes a mark space ratio modulator utilised for controlling a solenoid valve 21. Comparator 17, clutch actuator control 19, solenoid valve 21 and transducer 18 together constitute a clutch actuator control means which in conjunction with the actuator itself complete the control loop.

The solenoid valve controls the hydraulic flow in a hydraulic actuator 22. The actuator 22 operates the clutch 23 and the mark space ratio of the signal fed into the valve 21 determines the flow rate through the valve and hence controls the actuator 22 and therefore the state of engagement of the clutch.

The actuator 22 is operated by the control loop in response to the two signals C and S_T fed into the comparator 17, so that engagement of the clutch is controlled by the size of the command signal C.

When the engine speed signal V_1 is greater than

V_R the error signal E generated at the comparator 13 and the subsequent command signal C causes the clutch 23 to engage to make V_1 equalise with V_R and reduce the error signal to zero.

A wear compensator device 29 receives the error signal E and the command signal C. The compensation device 29 comprises a detect zero means 31 which receives the error signal E, a detect positive means 32 which receives the command signal C, and AND gate 33 which receives the signal from the two detect means 31 and 32. The AND gate also receives signals from a gearbox logic circuit 27 and a road speed sensor 28 so that the AND is open only when the logic circuit 27 has selected first gear, and the road speed is below 6 m.p.h., 6 m.p.h. corresponds with about 1500 rpm engine speed and is below the speed at which the clutch is fully engaged. The gate 33 switches in a 500 cycles/sec oscillator 34 when both the error signal is at zero and the command signal is positive. A binary counter 35 counts the number of oscillations for which the AND gate 33 is open and a digital analogue convertor 36 produces a signal S_W proportional to the number of oscillations which occur whilst the gate is open.

The clutch system operates as follows:—

When the vehicle is started and the engine idling the engine speed voltage V_1 is below the reference signal voltage V_R, giving rise to a positive error signal E and a negative command signal C. As the engine speed increases, when V_1 becomes equal to V_R the error signal E goes to zero and then as V_1 exceeds V_R the error signal becomes negative. The clutch starts to engage to maintain the error signal at zero and the command signal is at that moment positive.

Without a wear compensation device 29 the clutch position is dependant upon the balance between the transducer signal S_P and the command signal C and as the clutch plate wears, the control system takes a longer period of time before the engine speed is pulled down to 1000 rpm after V_1 exceeds V_R. This is because the feedback signal S_P is a reflection of the clutch position. To compensate for this, the wear compensation device 29 operates as follows:—

During the first clutch engagement as the clutch begins to engage, then at that instant with the vehicle in first gear and travelling at less than 6 m.p.h. both the command signal C is positive, because V_1 has overshot V_R, and the error signal E has reached zero. The gate 33 then switches in the oscillator 34 and the counter and converter and a signal S_W is generated, which is equivalent to the time for which the oscillator 34 is switched on by the gate. For a new clutch plate this oscillator count will be minimal. Once the clutch is engaged sufficiently to maintain engine speed at 1000 rpm, the command signal C goes to zero and the gate 33 switches off.

The counter 35 counts the number of oscillations for which the gate 33 was open and the digital-to-analogue converter 36 produces a constantly generated output signal S_W of amplitude proportional to the count, which is combined in a junction 37 with the clutch position signal S_P to reduce S_P to the signal S_T. This has the effect of causing the integrator command signal C to be reduced by a slight further engagement of the clutch so as to make C equal with the signal S_T.

As the clutch plate wear subsequently takes place then sp will increase to $S_p + dS_p$ and the oscillator count will increase and the converter will produce a new signal $S_W + dS_W$ equivalent to the increased count and the total signal S_T will remain constant. The apparatus is arranged to be switched on and off with the vehicle ignition system so that it is reset at every journey. However, the apparatus could be wired across the vehicle battery so that it is set on the first engagement of a new clutch plate and remains in the system until a new plate is fitted. The detail of the circuit of the wear compensating device is shown in Fig. 2.

The zero detect 31 comprises two amplifiers 41 and 42 one of which 41 is an inverting amplifier. The amplifier 42 operates (see Fig. 3) so that the input switches the amplifier to produce an output at say X volts but does not switch off against until the input falls to y volts. The hysteresis effect is determined by the size of the resistor 43 across the amplifier.

The amplifier 41 is an inverting amplifier in which the output is switched off when the input reaches x − dx volts and switches back on when input drops back to z volts (z is greater than y) (see Fig. 4). The hysteresis again being determined by the size of the resistor across the amplifier.

When the AND gate 33 executes an AND operation on the outputs from the two amplifiers 41 and 42 (see Fig. 5) then the AND gate will only switch a signal through for the period when both output signals from 41 and 42 have a high value. This causes a response window for an input between y volts and z volts when the input is falling so that wear detector is only switched on when the error signal is approaching zero as the clutch is engaging.

Now if the clutch take-up takes place at full throttle then the clutch plate will be in hard engagement with the driving members and the feedback signal S_P will be greater than normal, say $S_P + dS_P$ and therefore S_T will be larger than it should be. In order to compensate for this the throttle signal V_T which is reducing with increasing throttle opening, is combined with S_W.

At above 6 m.p.h. the AND gate closes and the wear compensator 29 is switched off. This ensures that the device does not function at every gear change and also by having the limit of 6 m.p.h., which is below the engine rpm at which the clutch is fully engaged, it is possible to ensure that the signal S_W is related to the position at which the clutch is in slipping engagement with the driving surfaces.

A second embodiment of the invention is shown in Figs. 6—8, in which those components common with the system as previously described with reference to Fig. 1 will be given the same reference numerals.

The system shown in Figs. 6 to 8 operates as previously described.

The comparator 13 receives the reference of AND engine speed signals V_1 and V_R and measures the difference between the two signals to produce the error signal E. When V_1 is less than V_R the error signal is greater than zero, when $V_1 = V_R$ the error signal is zero, and when V_1 exceeds V_R the error signal is less than zero.

When the engine speed signal V_1 is greater than V_R the error signal E generated at the comparator 13 and the subsequent command signal C causes the clutch 23 to engage to make V_1 equalise with V_R and make the error signal tend to zero.

A wear compensator device 129 receives the error signal E and the command signal C. The compensation device 129 comprises a detect means 131 which detects when the error signal is zero or just less, a detect high means 132 which receives the command signal C, and an AND gate 133 which receives the signals from the two means 131 and 132. The AND gate 133 also receives signals from the gearbox logic circuit 27 and the road speed detector 28 so that the AND is open only when the logic circuit 27 has selected first gear, and the road speed is below 6 m.p.h. The gate 133 also receives a signal from a throttle position differentiator 138 which is connected to the potentiometer 40 coupled to the butterfly valve in the vehicle carburettor. In this system the throttle potentiometer 40 is not, as previously, connected to the feedback signal S_P but is connected via a resistor 140 to the command signal take-off for the detect HIGH 32.

The gate 133 switches in a signal derived from a 1000 cycles/sec oscillator 134 when the error signal approaches zero and the command signal C is high, and all the other command signals are correct. The 1000 cycles/sec signal from the oscillator 134 is fed through a divider 142 which reduces the signal to 100 cycles/sec. A binary counter and analogue converter 35 counts the number of oscillations for which the AND gate 133 is open and produces a signal dSW_1 proportional to the number of oscillations for which the gate is open. This is the fine adjustment for the compensator. The signal dSW_1 is combined with a signal dSW_2 from a second AND gate 144 and is subsequently combined with the feedback signal S_P from the clutch position transducer 18 at a summing junction 143, to form the signal ST which is fed into the comparator 17.

The signal from the oscillator 134 is also fed into the second AND gate 144 which also receives a signal from a timer 145, and a comparator 146. The comparator 146 has its inputs connected to a reference voltage generator 147 and to the signal S_T. The AND gate 144 is open whilst the timer 145 passes a signal thereto (approx. 0.35 secs) and the comparator 146 is open. The comparator closes when the signal S_T approaches the preset signal from the reference generator 147. This is the coarse positional adjustment means for the compensator 29.

Detailed circuits of the oscillator 134 and timer 145 are shown in Fig. 8. This circuit takes up any engineering tolerances in the clutch actuation mechanism. When the clutch position potentiometer 18 is assembled in place onto the vehicle gearbox (not shown) the mechanical tolerances will cause the potentiometer to have a tolerance on its feedback signal S_P with respect to clutch position. When the potentiometer is fitted to a new clutch, it is set with the clutch release bearing just touching the clutch diaphragm spring fingers (or release levers, as the case may be). The clutch position reference generator 147 is set to a predetermined voltage above zero to ensure that the circuit is set for a condition when the clutch is fully engaged. When the vehicle ignition is switched on the circuit will count rapidly to produce a signal that will result in S_T being equal to the predetermined voltage so that as the clutch plate wears S_T is maintained at said voltage which corresponds to the clutch fully engaged condition.

When the vehicle ignition is switched on the timer 145 will hold the gate 144 open until its capacitor 161 charges and closes the gate 144. Whilst the gate 144 is open the oscillator 134 is feeding at 1000 cycles per second directly into the counter 135 to produce a signal dSW_2 until such times as the comparator 146 shuts off the gate 144. The timer 145 is arranged to remain open for a longer time period than will be required for the comparator 146 to operate. Thereafter every time the driver operates his ignition switch this circuit will produce an initial signal dSW_2 which will slowly alter as the clutch plate wears. The signal dSW_2 will ensure that the clutch plate is roughly in the correct position for maintaining a constant engine speed at clutch engagement and the signal dSW_1 will give a final adjustment to the clutch position.

In some instances it is possible for the clutch wear to be compensated for by means of the coarse positional adjustment means only.

The detect means 131 is shown in detail in Fig. 7 and comprises a threshold detector 151 which receives the error signal E and compares it with a fixed reference voltage which is just above zero. When the threshold detector 151 is triggered by the error signal approaching zero or going below zero, its output signal goes high and opens the AND gate 133 provided that all its other input conditions are met. When the detector 151 output goes high, it charges up capacitor 152 causing the input to a second threshold detector 153 to increase. The second detector 153 is an inverting amplifier and its normally higher output goes low when the amplifier 153 is triggered. The output from the second threshold detector 153 then pulls down the high output from the first detector 151 and closes the gate 133. The time lapse period for the capacitor 152 to charge up, and for which both detector outputs are high is approx. 1 second. If the error signal E suddenly goes high i.e. the engine speed signal V_1 drops below the reference voltage V_R, the detector 151 will switch low shutting off the gate 133. This will cause a tran-

sistor 154 to allow the capacitor 152 to discharge immediately so that if the error signal subsequently goes low, the capacitor 152 will require the full time lapse to charge.

The detect HIGH 132 comprises a threshold detector connected to a reference voltage (≏ zero) and a combined signal which is summed from the throttle potentiometer signal V_T and the clutch command signal C. The reference voltage is chosen to be always less than the combined command and throttle signal about 1000 rpm. When the command signal C goes high the threshold detector 132 is triggered and its output opens the gate 133 provided all its other input conditions are met.

The throttle differentiator 138 comprises an inverted threshold detector 155 whose output is connected to the gate 133. The detector 155 output is normally high to keep the gate 133 open but when triggered goes low closing the gate. The positive input to the detector 155 is connected to a reference voltage (≏ zero) and the negative input is connected to the throttle potentiometer 41 via a capacitor 156 and resistor 157. During acceleration whilst the output from the throttle potentiometer is decreasing the capacitor 156 effectively prevents triggering of the threshold detector 155. If the accelerator is suddenly released the throttle signal goes up and the capacitor 156 discharges a high signal input to the detector 155 causing it to trigger and its output to go low, thereby momentarily closing the gate. This has the effect of preventing the wear compensator from counting during those moments when the engine speed exceeds the reference due to inertia of the engine when the throttle is closed.

Also if the clutch take-up occurs at a high throttle opening the clutch plate engages fully with the driving member and the signal S_P is greater than it should be e.g. $S_P + dS_P$ and therefore the wear compensator 129 will operate and S_W will be larger than should be. In order to prevent this, the throttle signal from the potentiometer 40 is combined with the command signal take-off for the detect means 132. Since the throttle signal is decreasing with throttle opening, and the command signal goes high as the engine speed signal V_1 increases above V_R, then the combined signal remains substantially constant and switches off the gate 133 at a lower level of wear signal.

The clutch system operates as follows:—

When the vehicle is started and the engine idling the engine speed voltage V_T is below the reference signal voltage V_R, giving rise to a high error signal E and a low command signal C. As the engine speed increases V_1 becomes equal to V_R the error signal E goes to zero and then as V_1 exceeds V_R the error signal goes low. The clutch starts to engage to maintain the error signal zero and the command signal C is at that moment high.

When the ignition is first switched on the wear device produces an initial signal dSW_2 as previously described. During the first clutch engagement as the clutch begins to engage, then at that instant with the vehicle in first gear and travelling at less than 6 m.p.h., both the command signal C is high, because V_1 has overshot V_R, and the error signal E is approaching zero. Providing the trigger 155 in the differentiator 138 has not been triggered the gate 33 then switches in the oscillator 134 for a time period until either of the signals E or C changes to close the gates 133. The oscillator count through the gate 133 produces a signal dSW_1 which is combined with the signal dSW_2 to form the wear signal SW. For a new clutch plate this oscillator count for dSW_1 will be minimal. Once the clutch is engaged sufficiently to maintain $V_1 = V_R$ command signal C goes to zero and the gate 33 switches off.

The counter and converter 35 counts the number of oscillations for which both the gates 133 and 144 were open and produces a fixed output signal S_W which is proportional to the count, which is then combined in a summing junction 143 with the clutch position feedback signal S_P to form the signal S_T. This has the effect of allowing a slight further engagement of the clutch for a given engine speed signal V_1, thereby holding the engine speed at which the clutch engages substantially constant, even though wear to the clutch plate is taking place.

As wear subsequently takes place the oscillator count through the gate 133 will increase and produce an increased signal dSW_1 and thereby increase S_W.

Claims

1. An electronic control system for a rotary friction clutch in an engine driven vehicle for starting the vehicle from rest comprising a clutch control signal generator (11, 12, 13) which produces a control signal (E) in response to a vehicle operating parameter and from which a command signal (C) is derived which commands the state of engagement of the clutch (23), a clutch actuator control means (17, 18, 19, 21) responsive to the command signal (C) for operation of the clutch and including a comparator (17) that receives the command signal (C) and a transducer (18) responsive to the position of the clutch to produce a feedback signal (S_P) which is modified by a wear compensation signal (S_W) derived from a wear compensator (29) so that the feedback signal (S_P) is altered (to S_T) in dependence on the state of wear of the clutch, the altered feedback signal also being received by the comparator (17) characterised in that the command signal (C) is derived by integrating the control signal (E) in an integrator (14), the wear compensator (29 or 129) comprises a first detect means (31 or 131 respectively), for sensing the threshold value of the control signal (E) and a second detect means (32 or 132 respectively), for sensing when the command signal (C) has passed the threshold value, and a wear signal generator is responsive to detection of the threshold values of the control

signal and the command signal during an initial clutch engagement to set automatically a wear compensation signal (S_W) for subsequent clutch engagement.

2. A system as claimed in claim 1 characterised in that the control signal (E) is responsive to an engine speed signal (V_1) derived from an engine speed sensor (11) such that the engine speed is controlled to a constant level during clutch engagement.

3. A system as claimed in claim 2 characterised in that the wear signal generator includes a counter (35) which is started in response to the control signal (E) reaching a threshold level indicative that clutch engagement should commence ($E = 0$) and is stopped in response to the command signal (C) reaching a threshold level indicative that the clutch is engaged sufficiently to maintain the desired constant engine speed ($C = 0$).

4. A system as claimed in claim 3, characterised in that the first detect means (31 or 131 respectively), for sensing the threshold value of the control signal (E) produces an output signal for control of a first AND gate (33 or 133 respectively), and the second detect means (32 or 132 respectively), for sensing when the command signal (C) has passed the threshold value also produces an output signal for control of the first AND gate (33 or 133), said first AND gate (33 or 133) controlling the counter (35).

5. A system as claimed in any one of the preceding Claims, characterised in that the second detect means (32 or 132) is an amplifier connected between the command signal (C) and the first AND gate (33 or 133 respectively), and is triggered to open the first AND gate by the command signal voltage reaching or passing its predetermined threshold value.

6. A system as claimed in Claim 4, characterised in that the wear signal generator comprises an oscillator (34 or 134) that is switched on and off by the first AND gate (33 or 133 respectively), a binary counter (35) that counts the number of oscillations for which the AND gate is open, and a digital analogue converter (36) that produces a wear signal (S_W or dSW_1) commensurate with the number of counts.

7. A system as claimed in any one of Claims 5 to 7, characterised in that the threshold value of the control signal is zero and the first detect means is a detect zero (31) connected between the control signal (E) and the first AND gate (33) and comprising two amplifiers (41 and 42) connected in parallel to a second AND gate, said amplifiers each being connected to the control signal (E) by a different polarity input and being triggered at difference voltages so as to create a narrow signal band about zero for which the second AND gate is open thereby opening the first AND gate only within said band.

8. A system as claimed in Claim 7, characterised in that the second AND gate connected to the two amplifiers is combined with the first AND gate.

9. A system as claimed in any one of the preceding Claims, characterised in that a throttle position sensor (40) produces a throttle signal (V_T) indicative of the vehicle throttle opening and which is combined with the wear compensation signal (S_W) so as to further reduce the feedback signal (S_P) when the clutch is engaged at full throttle.

10. A system as claimed in any one of Claims 4 to 9, characterised in that the first AND gate (33 or 133 respectively) receives a signal from a vehicle gearbox logic circuit (27) so that the first AND gate (133) is only open when the gearbox logic has selected first gear.

11. A system as claimed in any one of Claims 4 to 9, characterised in that the first AND gate (33 or 133) receives a signal from a road speed sensor (28) so that the AND gate (33 or 133) is only open up to a predetermined road speed.

12. A system as claimed in Claim 5, characterised in that the first detect means (131) comprises a first threshold detector (151) whose output goes high when the control signal (E) falls to or below a threshold value.

13. A system as claimed in Claim 12, characterised in that the first threshold detector (151) has an automatic switch off device (152, 153, 154) which makes its output go low after a predetermined lapsed time period.

14. A system as claimed in Claim 13, characterised in that the switch-off device comprises a capacitor (152) connected to the output of the first detector (151) and a second threshold detector (153) whose input is connected to said output and which acts in the inverting sense so that its output goes low when the capacitor (152) is fully charged, and the output of the second detector (153) is also connected to the output of the first detector (151) so as to pull the first detector output low, when the second detector output is low.

15. A system as claimed in Claim 14, characterised in that the capacitor (152) has a switch connected (154) thereto so that said capacitor discharges (152) when the first threshold detector (151) output goes low.

16. A system as claimed in Claim 15, characterised in that the switch (154) is a transistor.

17. A system as claimed in any one of Claims 4 and Claims 10 to 16 when dependant upon Claim 5, characterised in that a throttle signal generator (40) produces a throttle signal (V_T) indicative of throttle opening and said signal (V_T) is combined with the command signal (C) take-off for the second detect means (132) so as to modify the input signal thereto.

18. A system as claimed in any one of Claims 4, and 10 to 17 when dependant upon Claim 5, characterised in that a throttle signal generator (40) produces a throttle signal (V_T) indicative of throttle opening and said signal (V_T) is connected to the first AND gate (133) via a differentiator (138) so that a sudden decrease in throttle opening closes the first AND gate (133).

19. A system as claimed in Claim 1, characterised in that the feedback signal (SP) is modified

by a coarse position signal (dSW_2) produced by coarse positional means which comprises a desired clutch position reference signal generator (147) connected to an input of a comparator (146), whose other input is connected to the feedback signal (S_P) and whose output is connected to an AND gate (144) for control of a wear compensation signal generator (134, 35, 36) for modification of the feedback signal, the comparator (146) closing the AND gate (144) and stopping the compensation signal (dsW_2) when the feedback signal approaches the value of the desired position signal.

20. A system as claimed in Claim 18, characterised in that the AND gate (144) is also controlled by a timer (145) operated by the vehicle ignition switch.

21. A system as claimed in Claim 19 or Claim 20, when combined with a system as claimed in any one of Claims 1 to 17, characterised in that said coarse position signal (dSW_2) is summed with the wear signal (dSW_2) prior to the combined signal being utilised to modify the feedback signal.

Patentansprüche

1. Elektronische Steuerungsanlage für eine Drehreibkupplung in einem motorgetriebenen Fahrzeug zum Starten des Fahrzeugs aus dem Stand, mit einem Kupplungssteuersignalerzeuger (11, 12, 13), der ein Steuersignal (E) in Ansprechung auf einen Fahrzeugbetriebsparameter erzeugt und von dem ein Befehlssignal (C) abgeleitet wird, welches den Einrückzustand der Kupplung (23) befiehlt, einer Kupplungsstellantriebsteuereinrichtung (17, 18, 19, 21), die ansprechend auf das Befehlssignal (C) zum Betrieb der Kupplung ist und einen Komparator (17), der das Befehlssignal (C) empfängt und einen Signalumformer (18) beinhaltet, der ansprechend auf die Stellung der Kupplung ist, um ein Rückführsignal (S_P) zu erzeugen, das durch ein Abnutzungsausgleichsignal (S_W) abgewandelt wird, das von einem Abnutzungsausgleicher (29) abgeleitet wird, so daß das Rückführsignal (S_P) in Abhängigkeit vom Abnutzungszustand der Kupplung (in S_T) geändert wird, wobei das geänderte Rückführsignal auch von dem Komparator (17) empfangen wird, dadurch gekennzeichnet, daß das Befehlssignal (C) durch Integrieren des Steuersignals (E) in einem Integrator (14) abgeleitet wird, der Abnutzungsausgleicher (29 oder 129) eine erste Wahrnehmungseinrichtung (31 bzw. 131) zum Feststellen des Schwellenwertes des Steuersignals (E) und eine zweite Wahrnehmungseinrichtung (32 bzw. 132) zum Feststellen, wenn das Befehlssignal (C) den Schwellenwert überschritten hat, aufweist und ein Abnutzungssignalerzeuger ansprechend auf die Wahrnehmung der Schwellenwerte des Steuersignals und des Befehlssignals während einer ersten Kupplungseinrückung ist, um das Abnutzungsausgleichsignal (S_W) für eine nachfolgende Kupplungseinrückung einzustellen.

2. Anlage nach Anspruch 1, dadurch gekennzeichnet, daß das Steuersignal (E) ansprechend auf ein Motordrehzahlsignal (V_1) ist, das von einem Motordrehzahlfühler (11) abgeleitet wird, derart, daß die Motordrehzahl auf einen konstanten Pegel während der Kupplungseinrückung eingesteuert wird.

3. Anlage nach Anspruch 2, dadurch gekennzeichnet, daß der Abnutzungssignalerzeuger einen Zähler (35) aufweist, der in Ansprechung darauf, daß das Steuersignal (E) einen Schwellenwert erreicht, der anzeigt, daß die Kupplungseinrückung beginnen sollte (E = 0), gestartet wird und in Ansprechung darauf, daß das Befehlssignal (C) einen Schwellenwert erreicht, der anzeigt, daß die Kupplung ausreichend eingerückt ist, um die gewünschte konstante Motordrehzahl (C = 0) aufrechtzuerhalten, gestoppt wird.

4. Anlage nach Anspruch 3, dadurch gekennzeichnet, daß die erste Wahrnehmungseinrichtung (31 bzw. 131) zum Feststellen des Schwellenwertes des Steuersignals (E) ein Ausgangssignal zur Steuerung eines ersten UND-Gatters (33 bzw. 133) erzeugt, und die zweite Wahrnehmungseinrichtung (32 bzw. 132) zum Feststellen, wenn das Befehlssignal (C) den Schwellenwert überschritten hat, auch ein Ausgangssignal zur Steuerung des ersten UND-Gatters (33 oder 133) erzeugt, wobei das erste UND-Gatter (33 oder 133) den Zähler (35) steuert.

5. Anlage nach irgendeinem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die zweite Wahrnehmungseinrichtung (32 oder 132) ein Verstärker ist, der zwischen das Befehlssignal (C) und das erste UND-Gatter (33 bzw. 133) geschaltet ist, und von der Befehlssignalspannung angesteuert wird, das erste UND-Gatter zu öffnen, wenn sie ihren vorbestimmten Schwellenwert erreicht oder überschreitet.

6. Anlage nach Anspruch 4, dadurch gekennzeichnet, daß der Abnutzungssignalerzeuger einen Oszillator (34 oder 134), der von dem ersten UND-Gatter (33 bzw. 133) ein- und ausgeschaltet wird, einen Binärzähler (35), der die Anzahl der Schwingungen, während denen das UND-Gatter offen ist, und einen Digital-Analog-Wandler (36) aufweist, der ein Abnutzungssignal (S_W oder dSW_1) erzeugt, das mit der Anzahl der Zähler übereinstimmt.

7. Anlage nach irgendeinem der Ansprüche 5 bis 7, dadurch gekennzeichnet, daß der Schwellenwert des Steuersignals null ist und die erste Wahrnehmungseinrichtung ein Nullerfasser (31) ist, der zwischen das Steuersignal (E) und das erste UND-Gatter (33) geschaltet ist und zwei Verstärker (41 und 42) aufweist, die parallel zu einem zweiten UND-Gatter geschaltet sind, wobei ein jeder der Verstärker mit dem Steuersignal (E) durch eine andere Polaritätseingabe verbunden ist und bei Differenzspannungen angesteuert wird, um ein schmales Signalband um null herum zu erzeugen, während dem das zweite UND-Gatter offen ist, wodurch das erste UND-Gatter nur innerhalb des Bandes geöffnet wird.

8. Anlage nach Anspruch 7, dadurch gekennzeichnet, daß das zweite UND-Gatter, das mit den

beiden Verstärkern verbunden ist, mit dem ersten UND-Gatter kombiniert ist.

9. Anlage nach irgendeinem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß ein Drosselklappenstellungsfühler (40) ein Drosselklappensignal (V_T) erzeugt, das den Öffnungsgrad der Fahrzeugdrossel anzeigt und das mit dem Abnutzungsausgleichsignal (S_W) kombiniert ist, um das Rückführsignal (S_P) weiter zu verringern, wenn die Kupplung bei Vollgas eingerückt wird.

10. Anlage nach irgendeinem der Ansprüche 4 bis 9, dadurch gekennzeichnet, daß das erste UND-Gatter (33 bzw. 133) ein Signal von einer Fahrzeuggetriebe-Logikschaltung (27) empfängt, so daß das erste UND-Gatter (133) nur offen ist, wenn die Getriebelogik den ersten Gang gewählt hat.

11. Anlage nach irgendeinem der Ansprüche 4 bis 9, dadurch gekennzeichnet, daß das erste UND-Gatter (33 oder 133) ein Signal von einem Straßengeschwindigkeitsfühler (28) empfängt, so daß das UND-Gatter (33 oder 133) nur bis zu einer vorbestimmten Straßengeschwindigkeit offen ist.

12. Anlage nach Anspruch 5, dadurch gekennzeichnet, daß die erste Wahrnehmungseinrichtung (131) einen ersten Schwellendetektor (151) aufweist, dessen Ausgang hoch ist, wenn das Steuersignal (E) auf einen oder unter einen Schwellenwert abfällt.

13. Anlage nach Anspruch 12, dadurch gekennzeichnet, daß der erste Schwellendetektor (151) eine automatische Abschaltvorrichtung (152, 153, 154) hat, die nach einem vorbestimmten abgelaufenen Zeitabschnitt seinen Ausgang niedrig macht.

14. Anlage nach Anspruch 13, dadurch gekennzeichnet, daß die Abschaltvorrichtung einen Kondensator (152), der mit dem Ausgang des ersten Detektors (151), und einen zweiten Schwellendetektor (153) aufweist, dessen Eingang mit diesem Ausgang verbunden ist und der im Umkehrsinn wirkt, so daß sein Ausgang niedrig ist, wenn der Kondensator (152) voll aufgeladen ist, und der Ausgang des zweiten Detektors (153) auch mit dem Ausgang des ersten Detektors (151) verbunden ist, um den ersten Detektorausgang nach unten zu ziehen, wenn der zweite Detektorausgang niedrig ist.

15. Anlage nach Anspruch 14, dadurch gekennzeichnet, daß der Kondensator (152) einen mit ihm verbundenen Schalter (154) hat, so daß der Kondensator entlädt (152), wenn der erste Schwellendetektor (151)-Ausgang niedrig ist.

16. Anlage nach Anspruch 15, dadurch gekennzeichnet, daß der Schalter (154) ein Transistor ist.

17. Anlage nach irgendeinem der Ansprüche 4 und Ansprüche 10 bis 16, wenn auf Anspruch 5 rückbezogen, dadurch gekennzeichnet, daß ein Drosselklappensignalerzeuger (40) ein Drosselklappensignal (V_T) erzeugt, das den Öffnungsgrad der Drossel anzeigt, und das Signal (V_T) mit dem Start des Befehlssignals (C) für die zweite Wahrnehmungseinrichtung (132) kombiniert ist, um das zugeführte Eingangssignal abzuwandeln.

18. Anlage nach irgendeinem der Ansprüche 4 und 10 bis 17, wenn auf Anspruch 5 rückbezogen, dadurch gekennzeichnet, daß ein Drosselklappensignalerzeuger (40) ein Drosselklappensignal (V_T) erzeugt, das den Öffnungsgrad der Drossel anzeigt, und das Signal (V_T) mit dem ersten UND-Gatter (133) über eine Differenzierschaltung (138) verbunden ist, so daß eine plötzliche Abnahme in dem Drosselöffnungsgrad das erste UND-Gatter (133) schließt.

19. Anlage nach Anspruch 1, dadurch gekennzeichnet, daß das Rückführsignal (S_P) durch ein grobes Stellungssignal (dSW_2) abgewandelt wird, das von einer groben Stellungseinrichtung erzeugt wird, die einen gewünschten Kupplungsstellungsbezugssignalerzeuger (147) aufweist, der mit einem Eingang eines Komparators (146) verbunden ist, dessen anderer Eingang mit dem Rückführsignal (S_P) verbunden ist, und dessen Ausgang mit einem UND-Gatter (144) zur Steuerung eines Abnutzungsausgleichssignalerzeugers (134, 35, 36) zur Abwandlung des Rückführsignals verbunden ist, wobei der Komparator (146) das UND-Gatter (144) schließt und das Ausgleichssignal (dsW_2) stoppt, wenn sich das Rückführsignal dem Wert des gewünschten Stellungssignals nähert.

20. Anlage nach Anspruch 18, dadurch gekennzeichnet, daß das UND-Gatter (144) auch durch ein Zeitglied (145) gesteuert wird, das von dem Fahrzeugzündschalter betätigt wird.

21. Anlage nach Anspruch 19 oder Anspruch 20, wenn mit einer Anlage nach irgendeinem der Ansprüche 1 bis 17 kombiniert, dadurch gekennzeichnet, daß das grobe Stellungssignal (dSW_2) mit dem Abnutzungssignal (dSW_2) aufsummiert wird, bevor das kombinierte Signal verwendet wird, um das Rückführsignal abzuwandeln.

Revendications

1. Système de commande électronique pour un embrayage à friction tournant d'un véhicule propulsé par un moteur, pour démarrer le véhicule depuis l'arrêt, comportant un générateur (11, 12, 13) de signal de contrôle d'embrayage qui produit un signal de contrôle (E) en réponse à un paramètre de fonctionnement du véhicule et dont est dérivé un signal de commande (C) qui commande l'état d'engagement de l'embrayage (23), un dispositif (17, 18, 19, 21) de commande d'actionneur d'embrayage réagissant au signal de commande (C) en faisant fonctionner l'embrayage et comprenant un comparateur (17) qui reçoit le signal de commande (C) et un transducteur (18) qui réagit à la position de l'embrayage en produisant un signal de réaction (S_P) modifié par un signal de compensation d'usure (S_W) provenant d'un compensateur d'usure (29) de manière que le signal de réaction (S_P) soit modifié (en S_T) en fonction de l'état de l'usure de l'embrayage, le signal de réaction modifié étant également reçu par le comparateur (17), caractérisé en ce que le signal de commande (C) est obtenu en intégrant le signal de contrôle (E) dans un intégrateur (14), en

ce que le compensateur d'usure (29 ou 129) comporte un premier dispositif de détection (31 ou 131) respectivement pour détecter la valeur seuil du signal de contrôle (E) et un second dispositif de détection (32 ou 132) respectivement pour détecter quand le signal de commande (C) a franchi la valeur seuil et en ce qu'un générateur de signal d'usure réagit à la détection des valeurs seuil du signal de contrôle et du signal de commande pendant un engagement initial de l'embrayage en réglant automatiquement un signal de compensation d'usure (S_W) pour un engagement ultérieur de l'embrayage.

2. Système selon la revendication 1, caractérisé en ce que le signal de contrôle (E) est fonction d'un signal (V_1) de vitesse du moteur provenant d'un capteur (11) de vitesse du moteur de manière que la vitesse du moteur soit commandée à un niveau constant pendant l'engagement de l'embrayage.

3. Système selon la revendication 2, caractérisé en ce que le générateur de signal d'usure comporte un compteur (35) qui est démarré en réponse au signal de contrôle (E) atteignant un niveau seuil indiquant que l'engagement de l'embrayage doit commencer (E = 0) et est arrêté en réponse au signal de commande (C) atteignant un niveau seuil indiquant que l'embrayage est suffisamment engagé pour maintenir la vitesse constante voulue (C = 0) du moteur.

4. Système selon la revendication 3, caractérisé en ce que le premier dispositif de détection (31 ou 131 respectivement) destiné à détecter la valeur seuil du signal de contrôle (E) produit un signal de sortie pour commander une première porte ET (33 ou 133 respectivement) et le second dispositif de détection (32 ou 132 respectivement) pour détecter si le signal de commande (C) a franchi la valeur seuil produit également un signal de sortie pour commander la première porte ET (33 ou 133) la première porte ET (33 ou 133) commandant le compteur (35).

5. Système selon l'une quelconque des revendications précédentes, caractérisé en ce que le second dispositif de détection (32 ou 132) est un amplificateur connecté entre le signal de commande (C) et la première porte ET (33 ou 133) respectivement, et est déclenché pour ouvrir la première porte ET par la tension du signal de commande atteignant ou franchissant sa valeur seuil prédéterminée.

6. Système selon la revendication 4, caractérisé en ce que le générateur de signal d'usure comporte un oscillateur (34 ou 134) qui est mis en marche et arrêté par la première porte ET (33 ou 133 respectivement) un compteur binaire (35) qui compte le nombre d'oscillations pendant lesquelles la porte ET est ouverte et un convertisseur numérique-analogique (36) qui produit un signal d'usure (SW ou dSW_1) correspondant au nombre de comptages.

7. Système selon l'une quelconque des revendications 5 à 7, caractérisé en ce que la valeur seuil du signal de contrôle est zéro et que le premier dispositif de détection est un détecteur de zéro (31) connecté entre le signal de contrôle (E) et la première porte ET (33) et comportant deux amplificateurs (41 et 42) connectés en parallèle à une seconde porte ET, lesdits amplificateurs étant connectés chacun au signal de contrôle (E) par une entrée de polarité différente et étant déclenchés à des tensions différentes de manière à créer une bande de signal étroite autour de zéro pour laquelle la seconde porte ET est ouverte, ouvrant ainsi seulement la première porte ET dans ladite bande.

8. Système selon la revendication 7, caractérisé en ce que la seconde porte ET connectée aux deux amplificateurs est combinée avec la première porte ET.

9. Système selon l'une quelconque des revendications précédentes, caractérisé en ce qu'un capteur de position de papillon (40) produit un signal de papillon (V_T) indiquant l'ouverture du papillon du véhicule et qui est combiné avec le signal de compensation d'usure (SW) de manière à réduire encore le signal de réaction (S_p) quand l'embrayage est engagé avec le papillon complètement ouvert.

10. Système selon l'une quelconque des revendications 4 à 9, caractérisé en ce que la première porte ET (33 ou 133 respectivement) reçoit un signal d'un circuit logique (27) de boîte de vitesse du véhicule de manière que la première porte ET (133) soit ouverte seulement quand la logique de boîte de vitesse a sélectionné le premier rapport.

11. Système selon l'une quelconque des revendications 4 à 9, caractérisé en ce que la première porte ET (33 ou 133) reçoit un signal provenant d'un capteur de vitesse par rapport à la route (28) de manière que la porte ET (33 ou 133) soit ouverte seulement jusqu'à une vitesse prédéterminée par rapport à la route.

12. Système selon la revendication 5, caractérisé en ce que le premier dispositif de détection (131) comporte un premier détecteur à seuil (151) dont la sortie passe au niveau haut quand le signal de contrôle (E) décroît jusqu'à une valeur seuil ou au-dessous.

13. Système selon la revendication 12, caractérisé en ce que le premier détecteur à seuil (151) comporte un dispositif de coupure automatique (152, 153, 154) qui fait passer sa sortie au niveau bas après l'écoulement d'une période prédéterminée.

14. Système selon la revendication 13, caractérisé en ce que le dispositif de coupure comporte un condensateur (152) connecté à la sortie du premier détecteur (151) et un second détecteur à seuil (153) dont l'entrée est connectée à ladite sortie et qui fonctionne dans le sens inverseur de manière que sa sortie passe au niveau bas quand le condensateur (152) est complètement chargé, et la sortie du second détecteur (153) étant également connectée à la sortie du premier détecteur (151) de manière à faire passer la sortie du premier détecteur au niveau bas quand la sortie du second détecteur est au niveau bas.

15. Système selon la revendication 14, caractérisé en ce que le condensateur (152) est con-

necté à un commutateur (154) de manière que ledit condensateur (152) se décharge quand la sortie du premier détecteur à seuil (151) passe au niveau bas.

16. Système selon la revendication 15, caractérisé en ce que le commutateur (154) est un transistor.

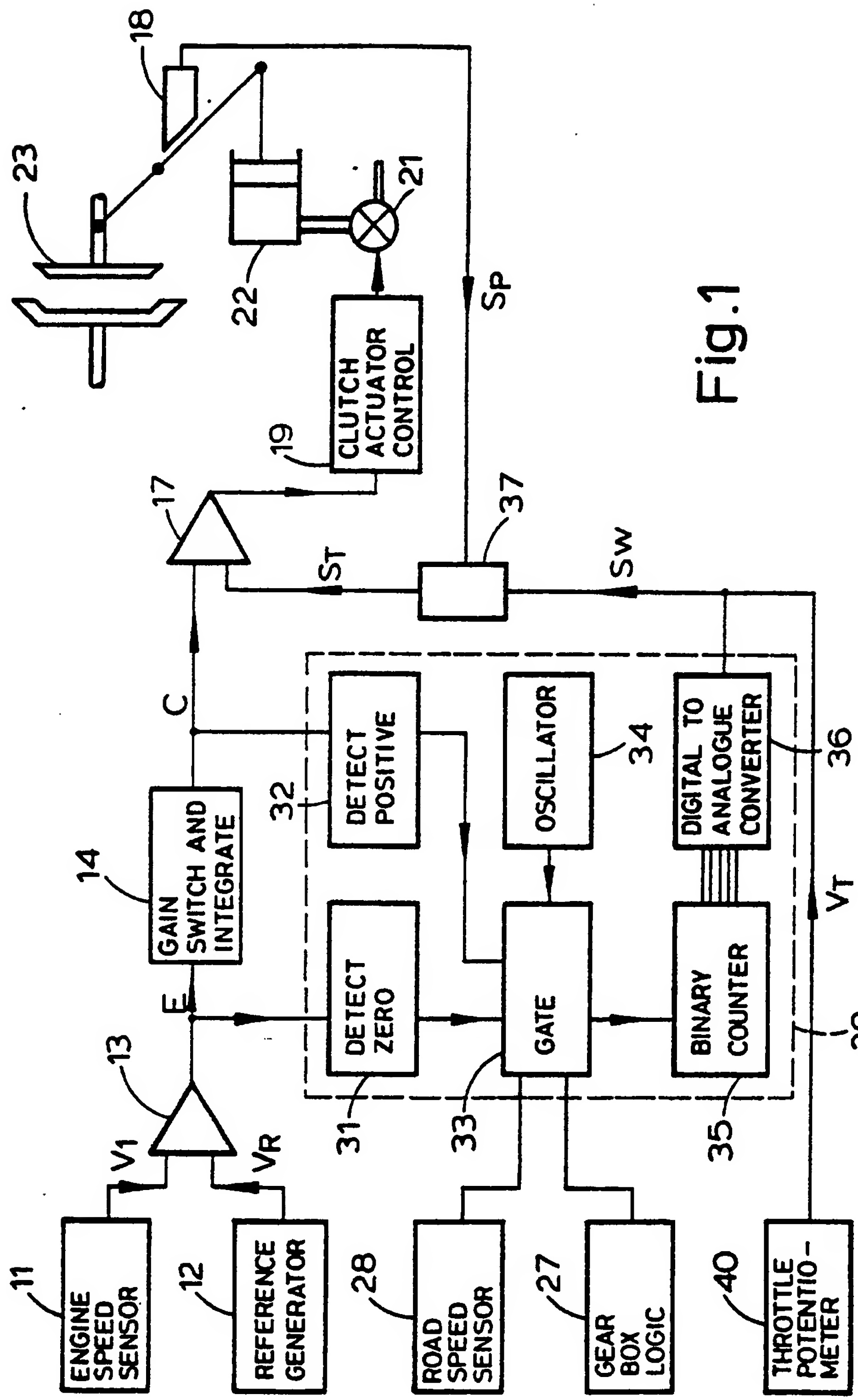
17. Système selon l'une quelconque des revendications 4 et 10 à 16, dépendante de la revendication 5, caractérisé en ce qu'un générateur (40) de signal de papillon produit un signal de papillon (V_T) indiquant l'ouverture du papillon, et ledit signal (V_T) étant combiné avec le prélèvement du signal de commande (C) pour le second dispositif de détection (152) de manière à en modifier le signal d'entrée.

18. Système selon l'une quelconque des revendications 4 et 10 à 17 dépendante de la revendication 5, caractérisé en ce qu'un générateur de signal de papillon (40) produit un signal de papillon (V_T) indiquant l'ouverture du papillon et ledit signal (V_T) étant connecté à la première porte ET (133) par un différenciateur (138) de manière qu'une diminution brusque d'ouverture du papillon ferme la première porte ET (133).

19. Système selon la revendication 1, caractérisé en ce que le signal de réaction (S_p) est modifié par un signal de position grossière (dSW_2) produit par un dispositif de positionnement grossier qui comporte un générateur (147) de signal de référence de position voulue d'embrayage connecté à une entrée d'un comparateur (146) dont l'autre entrée est connectée au signal de réaction (S_p) et dont la sortie est connectée à une porte ET (144) pour la commande d'un générateur (134, 35, 36) de signal de compensation d'usure destiné à modifier le signal de réaction, le comparateur (146) fermant la porte ET (144) et interrompant le signal de compensation (dSW_2) quand le signal de réaction s'approche de la valeur du signal de position voulue.

20. Système selon la revendication 18, caractérisé en ce que la porte ET (144) est également commandée par un temporisateur (145) actionné par le contact d'allumage du véhicule.

21. Système selon la revendication 19 ou la revendication 20, combiné avec un système tel que revendiqué dans l'une quelconque des revendications 1 à 17, caractérisé en ce que ledit signal de position grossière (dSW_2) est additionné avec le signal d'usure (dSW_2) avant que le signal combiné soit utilisé pour modifier le signal de réaction.


ENGINE SPEED SENSOR
REFERENCE GENERATOR
ROAD SPEED SENSOR
GEAR BOX LOGIC
THROTTLE POTENTIO-METER
GAIN SWITCH AND INTEGRATE
DETECT ZERO
DETECT POSITIVE
GATE
OSCILLATOR
BINARY COUNTER
DIGITAL TO ANALOGUE CONVERTER
CLUTCH ACTUATOR CONTROL
V1
VR
E
C
ST
SW
SP
VT
11
12
13
14
17
18
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21
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Fig.1

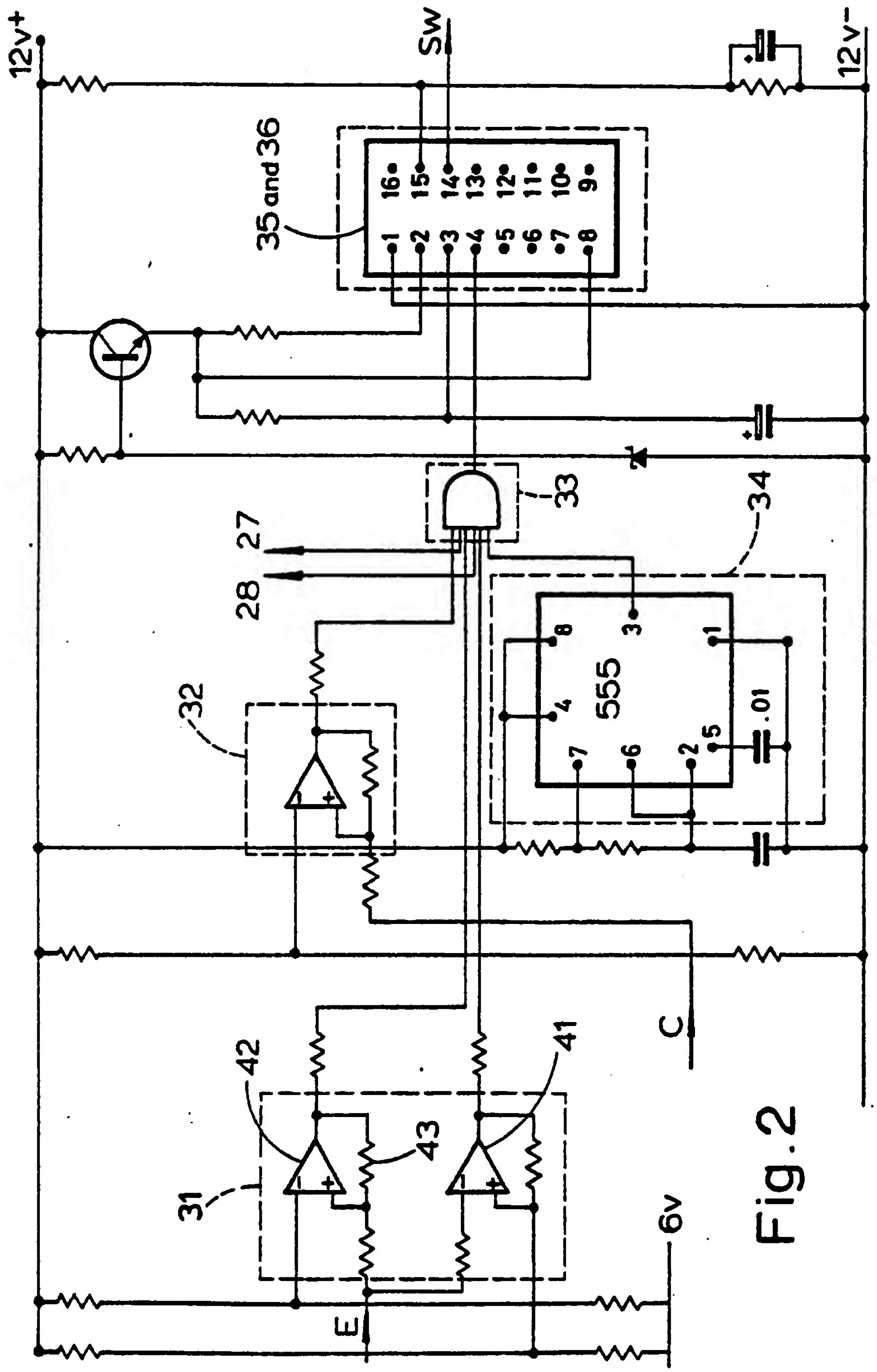

12v+
Sw
12v-
35 and 36
1
2
3
4
5
6
7
8
16
15
14
13
12
11
10
9
33
34
27
28
32
555
8
3
1
4
5
7
6
2
.01
31
42
43
41
C
6v
E

Fig. 2

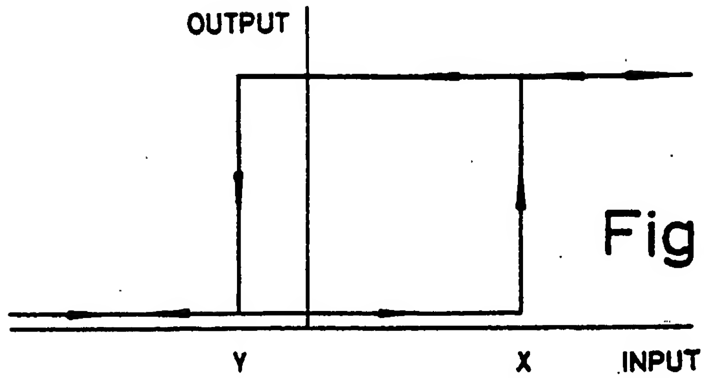


Fig.3

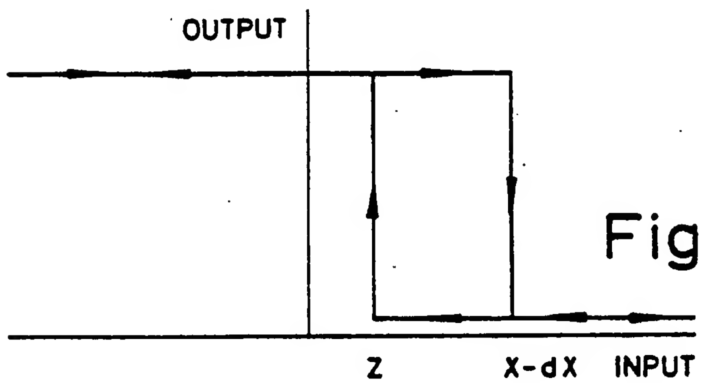


Fig.4

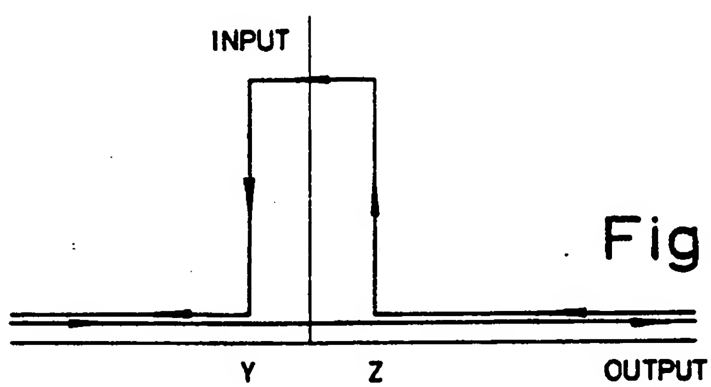
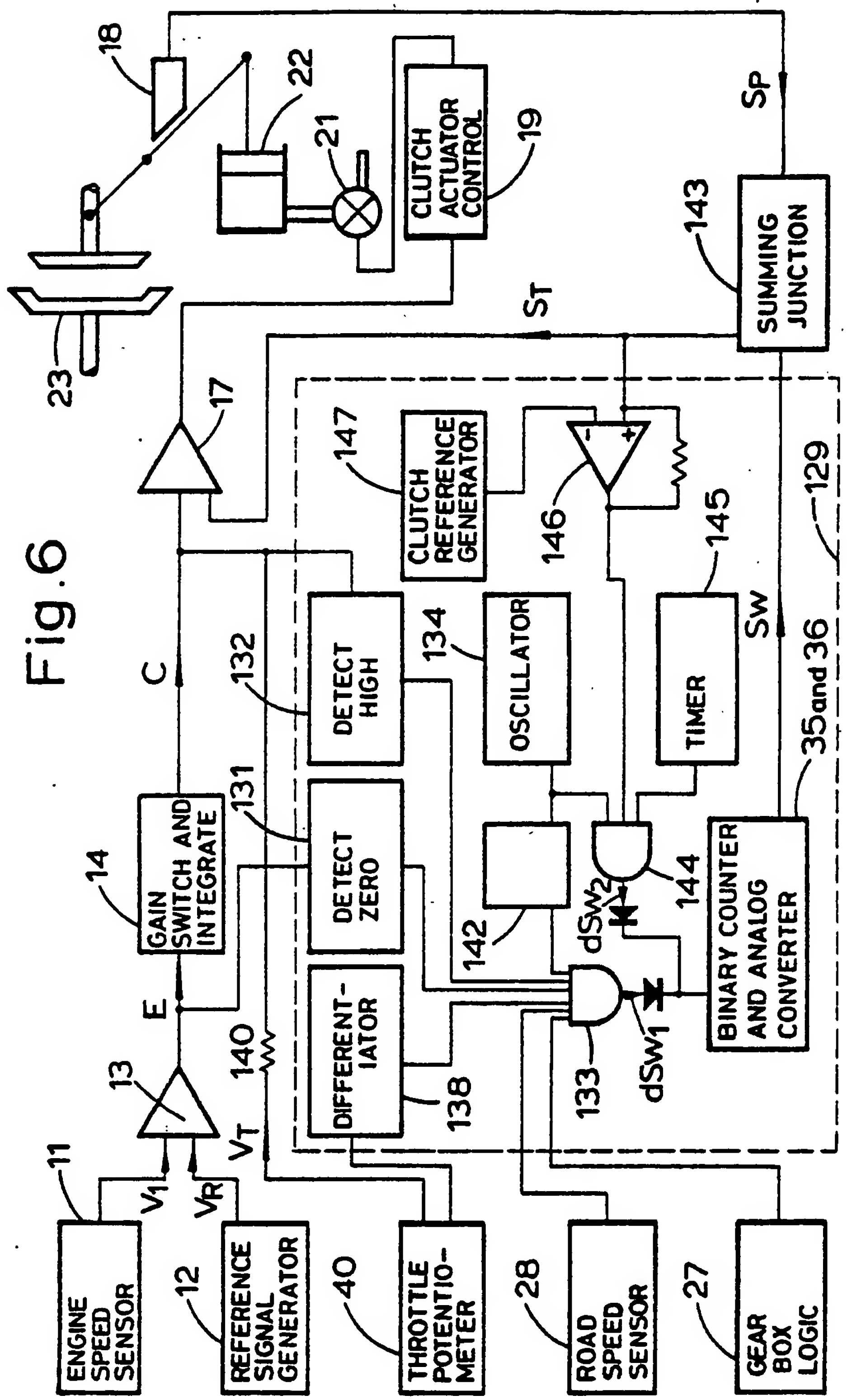
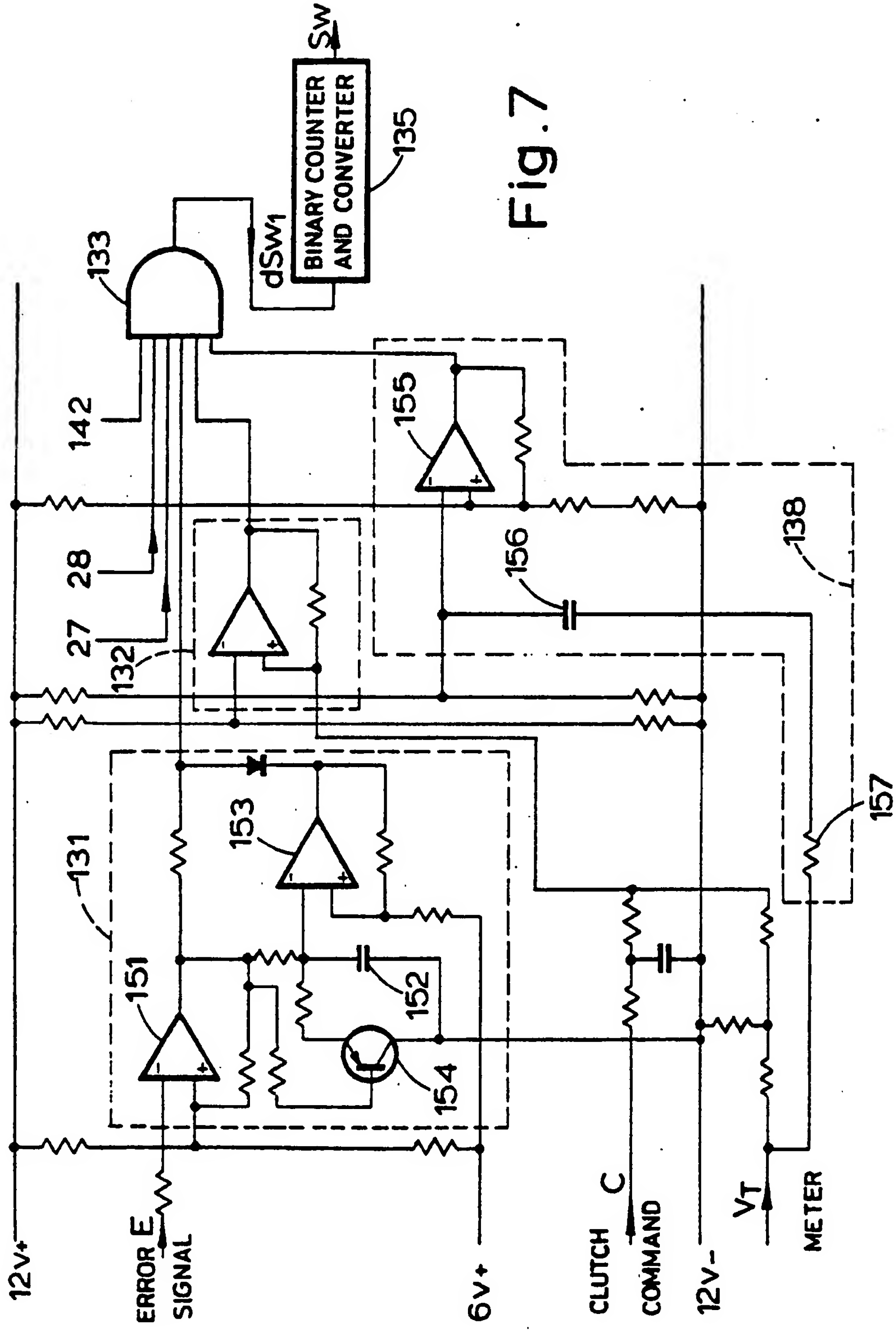


Fig.5



ENGINE SPEED SENSOR
11
REFERENCE SIGNAL GENERATOR
12
THROTTLE POTENTIO-METER
40
ROAD SPEED SENSOR
28
GEAR BOX LOGIC
27
V_1
V_R
V_T
13
E
140
GAIN SWITCH AND INTEGRATE
14
C
17
23
18
22
21
CLUTCH ACTUATOR CONTROL
19
S_T
S_P
SUMMING JUNCTION
143
DIFFERENT-IATOR
138
DETECT ZERO
131
DETECT HIGH
132
OSCILLATOR
134
CLUTCH REFERENCE GENERATOR
147
146
TIMER
145
142
144
133
dSw_1
dSw_2
BINARY COUNTER AND ANALOG CONVERTER
35and 36
Sw
129

Fig.6



12V+
ERROR E
SIGNAL
6V+
CLUTCH C
COMMAND
12V-
V_T
METER
131
151
152
153
154
132
27
28
142
133
dSw1
BINARY COUNTER
AND CONVERTER
135
Sw
155
156
138
157

Fig. 7

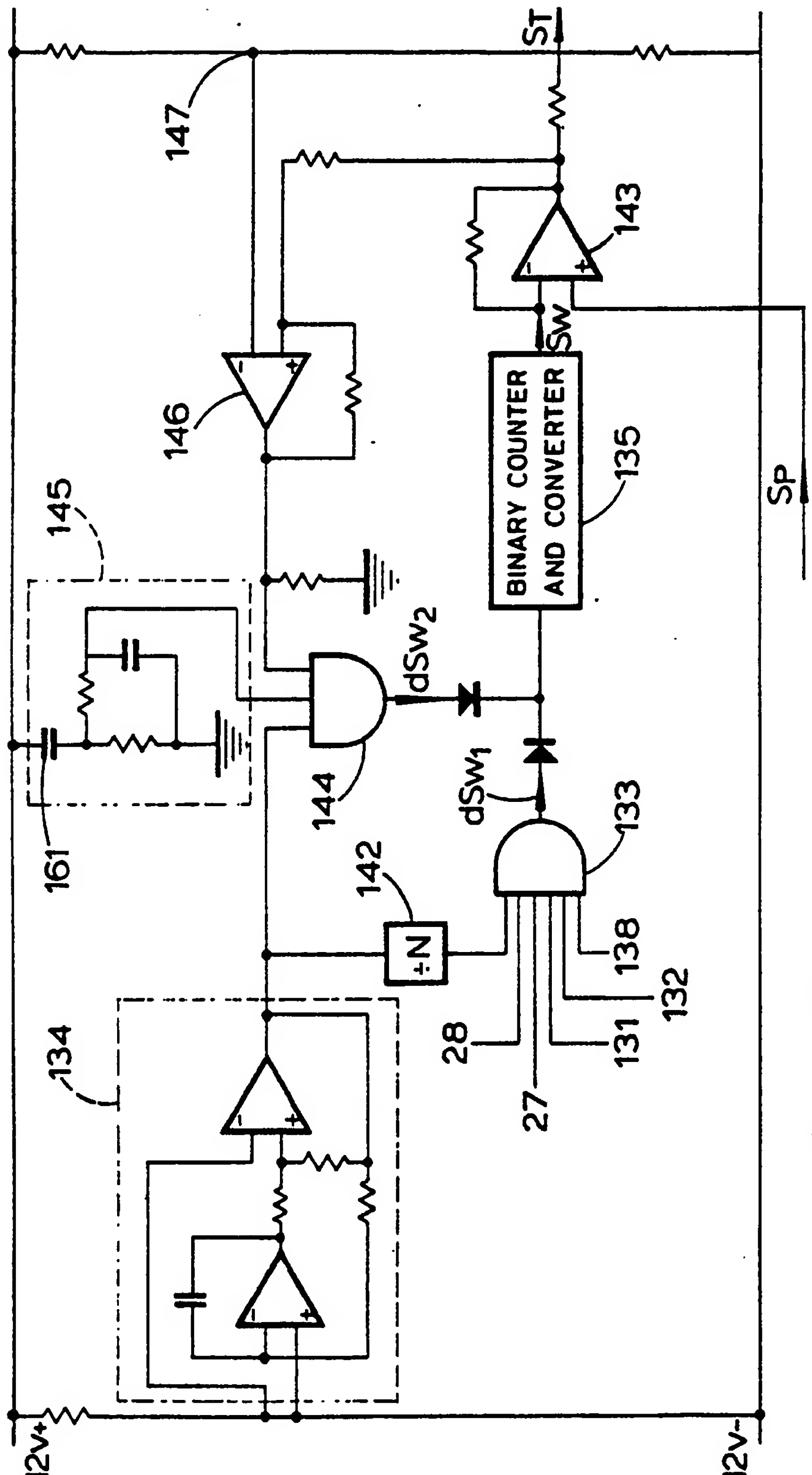

ST
147
143
146
SW
145
BINARY COUNTER
AND CONVERTER
135
SP
dSW2
144
161
dSW1
133
142
÷N
138
132
131
28
27
134
12V+
12V-

Fig.8